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AUTHOR: Zadikov, I. N.

TITLE: Some exact solutions of the energy equation for a plane parallel flow of a viscous incompressible fluid

PERIODICAL: Inzhenerno-fizicheskiy zhurnal, v. 5, no. 10, 1962, 3 - 8

TEXT: The boundary value problem

$$\frac{1}{a}\frac{\partial T}{\partial t}=\frac{\partial^2 T}{\partial y^2}+\frac{\mu}{\lambda}\frac{U_0^2}{h^2},$$
$$T(y,0)=T_0+\frac{\mu U_0^2}{2\lambda}\frac{y}{h}\left(1-\frac{y}{h}\right),\qquad (3)$$
$$T(0,t)=T_0,\quad T(h,t)=T_1.$$

is solved by the expression

$$\Theta=\eta+S\eta(1-\eta)+\frac{2}{\pi}\sum_{n=1}^{\infty}\frac{(-1)^n}{n}\sin(\pi n\eta)\exp(-\pi^2 n^2\beta),\qquad (4),$$

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where $\Theta=(T-T_0)/(T_1-T_0)$, $\beta=at/h^2$, $\eta=y/h$, and $S=(\mathrm{PrE})/2=\mu U_0^2/2\lambda(T_1-T_0)$. It is shown that for $S>1$ the cooling of the wall ceases at $\beta_{cr}=\nu t_{cr}/h^2$ and that its heating is due to the dissipation energy of the fluid. The figure illustrates the dependence of β_{cr} on S (the indices 1 and 2 refer to the steady and to the unsteady flow, respectively). For an unsteady flow, the temperature distribution is obtained only for $\mathrm{Pr}\gg 1$,

$$\Theta=\eta+S\eta(1-\eta)+(2/\pi)\sum_{n=1}^{\infty}(-1)^n\sin(\pi n\eta)\exp(-\pi^2 n^2\beta)/n-(8/\pi^3)S\sum_{n=1}^{\infty}(2n-1)^{-3}\sin[(2n-1)\pi\eta]\exp[-\pi^2(2n-1)^2\beta],\qquad (6)$$

and for $\mathrm{Pr}\ll 1$,

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$$\Theta=\eta+\frac{2}{\pi}\sum_{k=1}^{\infty}\frac{(-1)^k}{k}\sin(\pi k\eta)\exp(-\pi^2k^2\beta)+$$
$$+S\Big\{(\eta-\eta^2)[1+2\exp(-2\pi^2\alpha)]+\frac{8}{\pi^2}\exp(-\pi^2\alpha)(1-\cos\pi\eta)-\qquad (7).$$
$$-\frac{16}{\pi^2}\eta\exp(-\pi^2\alpha)+\frac{1}{\pi^2}(\cos 2\pi\eta-1)\exp(-2\pi^2\alpha)\Big\}.$$

Equation (6) can be used to calculate the temperature distribution in a lubricant ($\mathrm{Pr}\gg 1$) which takes up the play between the crank journal and the bearing when rapid changes occur in the rpm of the shaft. There are 3 figures.

ASSOCIATION: Gosudarstvennyy universitet imeni M. V. Lomonosova, g. Moskva (Moscow State University imeni M. V. Lomonosov)

SUBMITTED: April 18, 1962

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